Claims:

1. Method for ultrasound measurement of the opening surface area of a dynamic or irregular orifice (2) through which a fluid flows, in particular blood (3), and/or of the volumetric flow rate and/or flow volume through the orifice (2),

with evaluation of the backscatter, in particular the power spectrum of Doppler signals, of a measurement beam (7) and/or of a reference beam (8) whose spatial measurement area (10) lies within the spatial measurement area (9) of the measurement beam (7),

characterized in

that several measurement beams (7) with offset spatial, partially overlapping measurement areas (9) covering the orifice (2) completely and preferably several reference beams (8) with offset spatial measurement areas (10) are evaluated for determination of the opening surface area, the volumetric flow rate, the flow volume, and/or a value proportional thereto.

2. Method according to claim 1, characterized in that a central measurement area (9) of a measurement beam (7) is surrounded, in a rosette pattern, by several measurement areas (9) of further measurement beams (7).

3. Method according to claim 1 or 2, characterized in that, for each measurement beam (7), a reference beam (8) is evaluated whose measurement area (10) lies inside the measurement area (9) of the associated measurement beam (7), and/or that the measurement area (10) of a reference beam (8) lies centrally inside the associated measurement beam (7).

4. Method according to any one of the preceding claims, characterized in that the measurement area (9, 10) are located at least essentially in the same plane.

5. Method according to any one of the preceding claims, characterized in that in each case a measurement beam (7) and an associated reference beam (8) are detected and evaluated simultaneously.

6. Method according to any one of the preceding claims, characterized in that several measurement beams (7), in particular all measurement beams (7), are detected and evaluated iteratively in succession within one measurement or measurement period.

7. Method according to any one of the preceding claims, characterized in that several measurement beams (7), in particular all measurement beams (7), are evaluated cumulatively, in particular with overlaps of their measurement areas (9) being compensated, preferably in order to generate a power profile which is as homogeneous as possible across the entire area.

8. Method according to any one of the preceding claims, characterized in that several reference beams (8), in particular all reference beams (8), are detected and evaluated iteratively in succession within one measurement or measurement period, and/or that a measurement area (10) of a central reference beam is surrounded, in particular in a rosette formation, by several measurement areas (10) of further reference beams (8).

9. Method according to any one of the preceding claims, characterized in that the measurement area (10) of a reference beam (8) is moved or directed into the inside and/or the measurement area (9) of a measurement beam (7) is moved or directed into the area of a vena contracta of the fluid flow through the orifice (2).

10. Method according to any one of the preceding claims, characterized in that a reference beam (8) is chosen to form a reference value for all measurement beams (7), or the highest reference value of all the reference beams (8) is used as reference value for all the measurement beams (7).

11. Method according to any one of the preceding claims, characterized in that the reference values of several reference beams (8) are continuously determined and the position of the measurement areas (9, 10) is corrected as a function of the reference values during a measurement period, in particular so that the measurement area (10) of a central reference beam (8) remains within the vena contracta of the orifice (2).

12. Method according to any one of the preceding claims, characterized in that the reference values of several reference beams (8) are continuously evaluated during a measurement period, and the measurement areas (9, 10) of the reference beams (8) and/or of the measurement beams (7) are shifted during a measurement period when the reference value of the central reference beam (8) reaches or drops below the reference value of another reference beam (8), in particular with the measurement areas (9, 10) being displaced, preferably in parallel, into the direction from the central measurement area (10) to the measurement area (10) of the last-mentioned reference beam (8).

13. Method for ultrasound measurement of the opening surface area of a dynamic or irregular orifice (2) through which a fluid flows, in particular blood (3), and/or of the volumetric flow rate and/or flow volume through the orifice (2), preferably according to any one of the preceding claims,

with evaluation of the backscatter, in particular the power spectrum of Doppler signals, of a measurement beam (7) and/or of a reference beam (8) whose spatial measurement area (10) lies within the spatial measurement area (9) of the measurement beam (7),

characterized in

that the measurement area (9) of the measurement beam (7) is moved three-dimensionally beforehand in a search mode, while Doppler signals are continuously detected and are evaluated in respect of the occurrence of a Doppler spectrum characteristic of a vena contracta, so that thereafter, for determination of the opening surface area, the volumetric flow rate, the flow volume and/or a value proportional thereto, the measurement area (10) of the reference beam (8) is moved or directed into the inside or the measurement area (9) of the measurement beam (7) is moved or directed into the area of the vena contracta of the fluid flow through the orifice (2).

14. Method according to claim 13, characterized in that, in order to detect a vena contracta, the following are evaluated:

whether the mean speed exceeds a minimum value or is maximal,

whether the width of the speed spectrum falls below a maximum value,

whether the power or the power integral over the speed exceeds a minimum value or is maximal,

whether the Doppler spectrum shows an at least substantially continuous or constant line of maximal speed and/or

whether the speed spectrum at a given time, in particular at maximum speed, shows at least substantially a Gaussian distribution or normal distribution.

15. Method according to any one of the preceding claims, characterized in that, in the evaluation from the power spectra of the Doppler signals of the backscattered measurement beams (7) and/or reference beams (8), the opening surface area, the volumetric flow rate, the flow volume and/or a value proportional thereto is/are determined by integration of the power spectra and/or of the product of power and speed over the speed or the speed range and/or time.

16. Method according to any one of the preceding claims, characterized in that pulsed ultrasound Doppler signals are used.

17. Method according to any one of the preceding claims, characterized in that a transmit beam (12) is generated by means of a matrix array transducer (11) and directed to desired measurement areas (9, 10).

18. Method according to any one of the preceding claims, characterized in that the measurement beams (7) and/or reference beams (8) are detected by means of a matrix array transducer (11) as a function of the measurement areas (9, 10).

19. Method according to any one of the preceding claims, characterized in that, either in succession or simultaneously during a measurement period, the opening surface area, the volumetric flow rate, the flow volume and/or a value proportional thereto is/are determined separately for two or more separate orifices (2).

20. Method according to any one of the preceding claims, characterized in that the opening surface area, the volumetric flow rate, the flow volume and/or a value dependent thereon is/are displayed.

21. Device (1) for ultrasound measurement of the opening surface area of a dynamic and/or irregular orifice (2) through which a fluid flows, in particular blood (3), and/or of the volumetric flow rate and/or flow volume through the orifice (2),

with evaluation of the backscatter, in particular the power spectrum of Doppler signals, of a measurement beam (7) and/or of a reference beam (8) whose spatial measurement area (10) lies within the spatial measurement area (9) of the measurement beam (7),

characterized in

that the device (1) has a matrix array transducer (11) for generating a transmit beam (12) and for detecting the measurement beam (7) and reference beam (8),

> wherein the measurement area (9) of the measurement beam (7) can be moved three-dimensionally beforehand in a search mode, while Doppler signals can be continuously detected and can be evaluated in respect of the occurrence of a Doppler spectrum characteristic of a vena contracta, so that thereafter, for the determination, the measurement area (9) can be directed into the inside or into the area of the vena contracta of the fluid flow through the orifice (2), and/or
>
> wherein several measurement beams (7) with offset spatial, partially overlapping measurement areas (9) covering the orifice (2) completely and/or several reference beams (8) with offset spatial measurement areas (10) can be detected and evaluated for determination of the opening surface area, the volumetric flow rate, the flow volume and/or a value dependent thereon.

22. Device according to claim 21, characterized in that a central measurement area (9) of a measurement beam (7) is surrounded, in a rosette pattern, by several measurement areas (9) of further measurement beams (7).

23. Device according to claim 21 or 22, characterized in that, for each measurement beam (7), a reference beam (8) can be evaluated whose measurement area (10) preferably lies centrally within the measurement area (9) of the associated measurement beam (7).

24. Device according to any one of claims 21 to 23, characterized in that the measurement area (9) of a reference beam (7) lies centrally within the associated measurement beam (7).

25. Device according to any one of claims 21 to 24, characterized in that in each case a measurement beam (7) and an associated reference beam (8) can be simultaneously detected and evaluated.

26. Device according to any one of claims 21 to 25, characterized in that several measurement beams (7), in particular all measurement beams (7), can be detected and evaluated iteratively in succession within one measurement or measurement period.

27. Device according to any one of claims 21 to 26, characterized in that several measurement beams (7), in particular all measurement beams (7), can be evaluated cumulatively, in particular where overlaps of their measurement areas (9) can be compensated.

28. Device according to any one of claims 21 to 27, characterized in that several reference beams (8), in particular all reference beams (8), can be detected and evaluated iteratively in succession within one measurement or measurement period.

29. Device according to any one of claims 21 to 28, characterized in that a reference beam (8) can be chosen to form a reference value for all measurement beams (7), or the highest reference value of all the reference beams (8) can be used as reference value for all the measurement beams (7).

30. Device according to any one of claims 21 to 29, characterized in that the reference values of several reference beams (8) can be continuously determined, and the position of the measurement areas (9, 10) can be corrected as a function of the reference values during a measurement period, in particular so that the measurement area (10) of a central reference beam (8) remains within the vena contracta of the orifice (2).

31. Device according to any one of claims 21 to 30, characterized in that a measurement area (10) of a central reference beam (8) is surrounded, in particular in a rosette formation, by several measurement areas (10) of further reference beams (8).

32. Device according to claim 31, characterized in that the reference values of several reference beams (8) can be continuously evaluated during a measurement period, and the measurement areas (9, 10) of the reference beams (8) and/or of the measurement beams (7) can be displaced during a measurement period when the reference value of the central reference beam (8) reaches or drops below the reference value of another reference beam (8), in particular where the measurement areas (9, 10) can be displaced, preferably in parallel, into the direction from the central measurement area (10) to the measurement area (10) of the last-mentioned reference beam (8).

33. Device according to any one of claims 21 to 32, characterized in that the measurement area (10) of a reference beam (8) can be moved or directed into the inside and/or the measurement area (9) of a measurement beam (7) can be moved or directed into the area of a vena contracta of the fluid flow through the orifice (2).

34. Device according to any one of claims 21 to 33, characterized in that, in the evaluation from the power spectra of the Doppler signals of the backscattered measurement beams (7) and/or reference beams (8), the opening surface area, the volumetric flow rate, the flow volume and/or a value proportional thereto is/are determined by integration of the power spectra and/or of the product of power and speed over the speed and/or time.

35. Device according to any one of claims 21 to 34, characterized in that pulsed ultrasound Doppler signals can be generated and evaluated.

36. Device according to any one of claims 21 to 35, characterized in that the transmit beam (12) can be directed by means of the matrix array transducer (11) to desired measurement areas (9, 10).

37. Device according to any one of claims 21 to 36, characterized in that the measurement beams (7) and/or reference beams (8) can be detected by means of the matrix array transducer (11) as a function of the measurement areas (9, 10).

38. Device according to any one of claims 21 to 37, characterized in that, either in succession or simultaneously during a measurement period, the opening surface area, the volumetric flow rate, the flow volume and/or a value dependent thereon can be determined separately for several separate orifices (2).

39. Device according to any one of claims 21 to 38, characterized in that the device (1) has a display unit (14) for displaying the opening surface area, the volumetric flow rate, the flow volume and/or a value proportional thereto, in particular over the measurement period.

40. Device according to any one of claims 21 to 39, characterized in that, in order to detect a vena contracta, the following can be evaluated:

whether the mean speed exceeds a minimum value or is maximal,

whether the width of the speed spectrum falls below a maximum value,

whether the power or the power integral over the speed exceeds a minimum value or is maximal,

whether the Doppler spectrum shows an at least substantially continuous or constant line of maximal speed and/or

whether the speed spectrum at a given time, in particular at maximum speed, shows at least substantially a Gaussian distribution or normal distribution.

41. Device according to any one of claims 21 to 40, characterized in that the matrix array transducer (11) is fixedly monted, preferably held by a suitable support, in particular on the breast of a patient.

42. Device according to any one of claims 21 to 41, characterized in that a three-dimensional data set with the information of the spatial distribution of velocity and volume flow is obtained in the search mode and stored, in particular so that this data set can be used later to determine the occurrence of a vena contracta or

even the opening surface area, the volumetric flow rate, the flow volume and/or a value dependent thereon of the vena contracta.